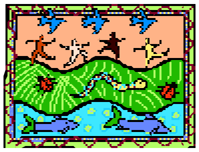
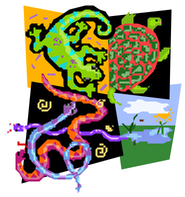
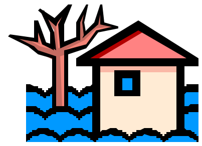
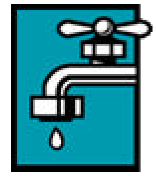
Best Available Science Review and Summary Papers

Designation and protection of critical areas is the first mandate of the Growth Management Act (GMA). Five types of critical areas are identified: Fish and Wildlife Habitat Conservation Areas, Wetlands, Frequently Flooded Areas, Critical Aquifer Recharge Areas, and Geologically Hazardous Areas. These areas need to be designated and mapped, and their functions and values protected.

Different types of critical areas are protected for different reasons. Fish and Wildlife Habitat Conservation Areas and Wetlands are protected primarily to preserve and maintain their ecological functions. Frequently Flooded Areas are protected partly to preserve ecological and hydrological functions of floodplains, and partly to prevent loss of property and human life caused by inappropriate development in floodplains. Critical Aquifer Recharge Areas are protected to maintain the quality of potable underground water supplies. Geologically Hazardous Areas are protected primarily to prevent loss of property and human life caused by inappropriate development and development in inappropriate areas.

The accompanying Summary and Review of Best Available Science papers for each GMA designated critical area has been prepared to demonstrate compliance with RCW 36.70A.172(1), *Critical areas -- Designation and protection -- Best available science to be used*. This section states, "In designating and protecting critical areas under this chapter, counties and cities shall include the best available science in developing policies and development regulations to protect the functions and values of critical areas." This language was added to the Growth Management Act in 1995 to ensure that jurisdictions include reliable scientific information.

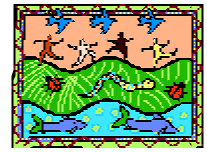
Science plays a central role in delineating critical areas, identifying functions and values, and recommending strategies to protect their functions and values. Local governments are required to identify, collect, and assess the available scientific information relating to the protection of critical areas within their jurisdiction, and then determine which of that science constitutes the "best available science". Scientific based recommendations cannot simply be disregarded in favor of competing considerations. Science that has not been filtered through screens of competing interests is required to make informed decisions.

The Best Available Science (BAS) Rule, WAC 365-195-900 through 925 took effect August 27, 2000. This rule does the following: explains the statutory context and purpose of the new BAS rules; explains what is “best available science”; offers recommendations as to where local governments can obtain the best available science; provides criteria for demonstrating that the best available science has been included in the development of critical areas policies and regulations; explains what to do if a county or city cannot find enough scientific information applicable to its critical areas; and explains what it means to give “special consideration” to the protection of anadromous fisheries.

RCW 36.70A.172(1), *Critical areas -- Designation and protection -- Best available science to be used*, establishes the requirement that jurisdictions give special consideration to conservation or protection measures necessary to preserve or enhance anadromous fisheries. This requirement to focus on protection measures for anadromous fisheries is further explained in WAC 365-195-925 of the BAS Rule.

The summary papers are written to give a basic understanding of the critical area topic. They are structured as follows: a definition and description of the critical area; a general summary of the critical area occurrence in Redmond; functions and values of the critical area; and key protection strategies for the critical area.

The City heavily relied upon the BAS literature review developed by King County, information developed as part of the Water Resource Inventory Area (WRIA) 8 and Shared Salmon Strategy programs, and scientific information available through state and federal resource agencies. Individual materials reviewed and incorporated into comprehensive documents, such as King County’s BAS materials review and the WRIA 8 and Shared Salmon Strategy materials are not listed. Reference materials used in these documents are cited in their respective appendices. Additional source information reviewed can be found in the City’s Best Available Science reference list.



Fish and Wildlife Habitat Conservation Areas

Definition/Description

Fish and wildlife habitat conservation is the management of land for maintaining species in suitable habitats within their natural geographic distribution so that isolated subpopulations are not created. This does not mean that all individuals of a species must be maintained at all times, but it does mean cooperative and coordinated land use planning is critically important among counties and cities in a region. Fish and Wildlife Habitat Conservation Areas include: areas with which endangered, threatened, and sensitive species have a primary association; habitats and species of local importance; naturally occurring ponds under twenty acres and their submerged aquatic beds that provide fish or wildlife habitat; waters of the state; and areas critical for habitat connectivity.

Wildlife areas are ecosystems composed of unique interacting systems of soils, geology, topography, and plant and animal communities. An ecosystem is defined as a physical system with an associated community of interacting organisms through which energy flows and material cycles. Ecosystems are components of the landscape. Landscape, ecosystems, and populations are interconnected through physical and biological processes and structures. Relationships exist between these units at every level of organization and there is a constant flow of energy and materials through the ecosystem that results in complex patterns of association at many scales of association. This dynamic development can be characteristically unpredictable. Many wildlife species have complex life cycles that require various ecosystems and habitats for breeding, feeding, and shelter.

Aquatic areas are rivers, streams, lakes, ponds and wetlands. The most basic functions of an aquatic area are the storage, purification, or transport of waters. In doing so, they also function as habitat for water-dependent plants and animals. These habitats and the species that use them are integrated parts of an aquatic ecosystem that has developed and continues to develop due to an array of climatic, geologic, and plant and animal (including humans) interactions.

The Growth Management Act requires cities and counties shall give special consideration to conservation and protection measures necessary to preserve or enhance anadromous fisheries. Anadromous fisheries refers to fish that spawn in freshwater, then after a period of time migrate into, grow, and mature in marine waters, ultimately returning a year or more later to their natal streams as mature fish. The lifestages of anadromous fish can be tied to the following general habitat requirements:

adequate but not excessive stream flows; cool, well-oxygenated, unpolluted water; streambed gravels that are relatively free of fine sediments; instream structural diversity; unimpeded migratory access to and from spawning and rearing areas; and complex estuarine and nearshore habitats that support food production, migratory cover, and physiological transition between fresh and salt water. All of these habitat requirements and life cycle needs should be given special consideration when developing critical area protection programs.

Salmonids are considered keystone species and are a commonly used benchmark for setting protection standards and assessing the effectiveness of aquatic habitat protection and restoration measures. They are the region's most diverse family of freshwater and anadromous fish, and exhibit exceptionally high life history diversity both within and among species. Development can have profound effects on salmonids. Studies have found that fish species diversity declined with increasing levels of urban development and that cutthroat trout became the dominant salmonid species in small draining heavily urbanized catchments in the Lake Washington watershed. Systematic declines in salmon abundance in Puget lowland streams relates to changes in flood frequency caused by urbanization.

Other indicator species include amphibians and mollusks. Amphibians are less mobile and have less tolerance for change. Mollusks have been noted as being good measure for environmental change as they can be sensitive to changes in water quality and fine sediments, as well as being relatively immobile. Additionally, benthic invertebrates (insects, crustaceans, and mussels) and fish were used in the development of indices of biotic integrity (IBI). This evaluates the presence and abundance of pollutant tolerant and pollutant intolerant species to gage the biological effect of pollution and other changes.

Fish and Wildlife Habitat Conservation Areas in Redmond

Considering Redmond is a designated Urban Growth Area, a fair amount of wildlife exists in the city. The majority of the wildlife occurs along river and stream systems, wetlands, and forested hillsides and ravines. The City developed a map of Potential Critical Wildlife Habitat as a resource tool to help understand the dynamic and interactions of wildlife populations and ecosystems present. The map includes habitat areas that have a primary association identified with endangered, threatened, or sensitive species, habitats and species of local importance, and areas critical for habitat connectivity.

Fish species can be found throughout Redmond's streams and river systems. Six species of salmon are know to currently be present in the overall Sammamish River watershed. These are Chinook, coho, and sockeye salmon, kokanee, and steelhead and cutthroat trout. Chum salmon occasionally stray into the watershed, but are not know to be a sustaining population. Puget Sound Chinook was listed as a threatened species under the Endangered Species Act in the late 1990's. Other fish species know to be present in the Sammamish River and its tributaries include native species such as longfin smelt, northern pike minnow, peamouth chub, three-spine stickleback, largescale sucker, longnose dace, brook lamprey, and several species of sculpin. Non-native fish include yellow perch, smallmouth bass, largemouth bass, brown bullhead, warmouth, pumpkinseed sunfish, tench, and carp. Predation by non-native fish species on salmon fry and juvenile may be a significant issue in the Sammamish River, although little sampling has occurred to verify this theory.

Bear Creek is one of the most productive salmon spawning systems in the Sammamish Basin. Currently, Bear Creek and its tributaries support populations of salmonids including Chinook, coho, sockeye, and kokanee salmon, steelhead and rainbow trout, and coastal cutthroat trout.

Functions and Values

Large terrestrial areas facilitate migration, dispersal, and other activities crucial to wildlife populations. Concurrently, these inclusive wildlife areas protect air and water quality, and provide other critical ecological processes and functions that contribute to the conservation of healthy habitats and ecosystems. In urban areas, humans and their activities determine land cover, displace wildlife, or otherwise influence their ability to retain species and viable populations through habitat loss or its alteration and fragmentation.

Water-generated energy and the chemical properties of water lay the foundation for the formation and function of aquatic areas. Movements of water generate the energy necessary to scour, transport, and deposit sediments. The chemical properties of water allow for the dissolution, suspension, or absorption of materials – including fine sediments, nutrients, and chemical compounds – adding to water's habitat forming capabilities. Acting together, these properties shape or set the template for many of the processes that form and determine the productivity of aquatic habitats.

Equally important in the development of aquatic areas are glaciers, forests, and animals. Glaciers have shaped the region's river valleys and river channels, left behind important features including extensive till and outwash-based plains, containing spring, lakes, and ponds. They also influenced the soils. The type of soil heavily influences the hydrology of aquatic areas. Forest areas' canopy, understory, accumulated organic matter, and surface soils intercept and store the vast majority of storm precipitation and subsequently gradually release it to aquatic habitats and underlying areas. Forests also serve as a source of nutrients upon which other plants and animals thrive, is important in water sediment and nutrient storage and cycling, and helps create structurally and functionally diverse aquatic habitat. Large and small woody debris interacts with water and sediment to create localized sediment scouring and deposition. In streams, woody debris generates pools and riffles provide habitat for migration, spawning, rearing, and refuge from periodic disturbances. In all aquatic environments, woody debris increases the amount, diversity, and quality of cover for resting, foraging, and predator avoidance.

Beavers and Pacific salmon are a few of the best examples of aquatic animals that modify their own environment. Beavers dam extensive segments of small stream channels and riverine valley floors altering flow and sediment deposition patterns thus creating habitat. Salmon can reshape areas of streams by loosening gravels during excavation of their nests, and in the process improve spawning substrates by releasing fine sediments and organic matter. They deposit large amounts of marine derived nutrients that boost aquatic food chain productivity and survival of their juveniles as well as nourishing many other plants and aquatic and terrestrial animals.

Development that occurs within or at the edge of aquatic areas can affect the quantity and quality of aquatic habitats by directly eliminating a habitat or altering natural processes that support it, such as bank erosion, channel migration, and the delivering and transport of sediment and woody debris. Effects of such activities include changes in currents, amount and transport rates of sediment and woody debris, changes in nighttime ambient light levels, introductions of toxic chemicals, and reductions in the quantity and quality of habitat. Development in floodplains and riparian corridors affects aquatic areas when it removes or modifies native forest vegetation, or when it alters rates and patterns of bank and channel erosion, migration, and surface and groundwater flow. Riparian area functions, such as shade, temperature control, water purification, woody debris recruitment, channel bank erosion, sediment delivery, and terrestrial based food supply, are potentially negatively affected when riparian development occurs. Development that occurs away from water has the potential to affect aquatic habitat primarily by modifying water storage and runoff patterns and sediment erosion rates.

Natural riparian corridors are essential for wild fish populations. Healthy riparian zones are dynamic ecosystems that perform various functions that form salmonid habitat. Some of the major functions include : producing and delivering large and small woody debris to shorelines and stream channels (reduced large woody debris is deemed a major reason for salmonid decline in Pacific Northwest streams); shoreline protection and habitat formation; removing sediments and dissolved chemicals from water; moderating water temperature; providing favorable microclimate (humidity, temperature, and wind speed); providing habitat for terrestrial animals; and providing proper nutrient sources for aquatic life. Other riparian functions important to salmonids includes exchange of water between the ground and the waterbody, flux of gravel between stream beds and banks, and light patterning which salmonids use for concealment.

Key Protection Strategies

There are a number of things that may be considered when classifying and designating Fish and Wildlife Habitat Conservation Areas. These include: creating a system of fish and wildlife habitat with connections between larger habitat blocks and open space; providing for some level of human activity in such areas, for example the presence of roads and some level of recreation; protecting riparian ecosystems; evaluating land uses surrounding ponds and fish and wildlife habitat areas that may negatively impact these areas; establishing buffer zones around these areas to separate incompatible uses from the habitat areas; and restoring lost salmonid habitat.

There are two approaches to conserving wildlife and their habitat. The first is to protect species only within clearly identified ecological reserves that are relatively homogeneous in plant composition and structure regardless of adjoining land uses. The second approach attempts to protect all species across an entire region by enhancing the quality of existing habitat and by providing for all important wildlife needs. The latter approach is more difficult to implement. Both approaches address the protection of ecological function, composition and structure. These approaches are more difficult to implement in urban environments than larger forested areas and more natural landscape.

Wildlife habitat protection should be based on several internal (site-specific) and external (contextual) habitat considerations. Internal conditions include: structural diversity (horizontally and vertically) of the habitat; edge conditions; presence of snags or large trees; presence of downed logs; and presence or nearness of water and its safe accessibility. External conditions include: the size of the habitat patch; ability of the habitat to serve as a corridor or link to other otherwise isolated natural areas, parks, preserves, or open spaces; the area is surrounded by a buffer or serves as a buffer; and the surrounding habitat types or land uses.

Wildlife habitat management in urban areas is extremely difficult because of competing and simultaneous demands on the land. Trade offs between wildlife benefits and urban benefits are virtually inescapable. Puget Sound studies suggest urban development be limited to fifty-two percent (52%) of the landscape, sixty-four percent (64%) of the remaining forest kept aggregate, and individual landowners maintain twenty-three percent (23%) conifers in the canopy and maintain tree density around four (4) trees per acre in order to conserve native forest species in an urban environment. Restoration of wildlife habitat should not be underestimated for reversing the loss of wildlife. Strategic planning, including protection, restoration, and management of wildlife can significantly contribute to the persistence and recovery of certain populations.

To conserve individual species and populations, a comprehensive approach that protects all habitat needs is required. Buffer zones are useful tools to protect raptors, for example, during breeding. However, protection of a nest tree is only a small part of that species' survival needs, and consequently, insufficient. The population must be understood within its daily and seasonal home range and greater landscape context. Knowledge of life histories is helpful and a detailed understanding of each species is important for effective management. The Washington Department of Fish and Wildlife provides distributions, descriptions, and management guidelines for priority species and habitats. This information is useful for establishing strategies for individual species.

One approach that land managers and regulatory agencies have implemented to alleviate impacts on wildlife habitats and species within human-influenced environments includes the establishment of wildlife habitat corridors. Corridors can provide a variety of functions for flora and fauna at both the local and regional landscape special scale, including: providing a means for animals to move between habitats daily and seasonally; enabling animals to disperse from one patch to another; reducing species extinction rates by ensuring that populations or individuals are not isolated from others in the landscape (population sink); guarding against detrimental genetic effects (inbreeding, depression, and random genetic drift); providing increased foraging habitat for a variety of species; providing predator escape cover for animals as they move between patches; and providing an avenue for vegetative communities to maintain reproductive viability and colonize new areas. It has, however, been argued that corridors may degrade naturally occurring habitats and populations in some situations. Corridors can transmit disease, fire, and predation. The disadvantages of corridors could be avoided or mitigated by sound ecological principles. Most of the natural landscape habitats were historically connected and corridor establishment attempts to mimic in a managed landscape the natural biological processes that historically occurred. Corridor establishment has been generally accepted to provide more ecological advantages than disadvantages, and corridors are considered an essential component for promoting ecological processes in landscapes.

As with other Critical Areas, the functions and values of Fish and Wildlife Habitat Conservation Areas must be protected. In addition, as mentioned above, the GMA also requires special consideration be given to conservation and protection measures to preserve or enhance anadromous fisheries. In order to achieve these goals, it is necessary to protect or restore the processes that sustain habitats, not just the habitats themselves. A generalized strategy is to first protect the best remaining habitats and then, to the extent feasible, restore those that are impaired. Placing a high priority on protecting areas with high habitat restoration or species recovery potential is consistent with recommendations for protection of aquatic resources in developing areas and for salmonid recovery. Relatively high protection of headwater areas and their streams may offer the greatest systemic benefits for the protection of certain functions, such as water quality protection, hydrology, and sediment routing, critical to streams.

Effective protection measures should provide protection for both critical habitat as well as ecological processes that sustain them. These ecological processes include water flow, sediment routing, vegetation succession, woody debris processing, and plant and animal speciation. This implies having regulations that protect habitats from direct harm from in-water and riparian activities as well as protecting key riparian and upland functions that sustain aquatic habitats.

The State uses “fish bearing versus non-fish bearing” status to separate major different categories of streams. The City of Redmond, however, presently uses the more restrictive “salmonid bearing versus non-salmonid-bearing” criterion to separate major stream classes. That is, streams with non-salmonid fish get no added protections in Redmond.

The State DNR is presently revising its current Type 1 through Type 5 water typing policy, which is to be replaced with a new habitat-based system (Type S, F, Np, and Ns). The new system uses an extensively field tested model to delineate waters of the State into three categories: type S waters (Shorelines of the State/SMA); type F waters (fish habitat); and type N waters (non-fish habitat). The present Redmond stream classification (Class I-IV, plus ‘intentionally created streams’) does not readily align with either the current or proposed State systems. As a result, data collected from Redmond’s streams cannot be readily included in, or compared with, any State databases or regulatory requirements.

Current State Water Types	**Proposed State Water Types**	**Current Redmond Stream Classes**
1- Shorelines of the State	S- Shorelines of the State	I- Shorelines of the State
2- High fish, wildlife, or human use	F- Fish habitat	II- Perennial or seasonal, with salmonids or the potential for salmonids
3- Moderate to slight fish, wildlife, and human use		
4- Perennial non-fish habitat	Np- Perennial non-fish habitat	III- Perennial or seasonal, without salmonids or potential for salmonids
5- Seasonal non-fish habitat	Ns- Seasonal non-fish Habitat	IV- Perennial or seasonal flow, without salmonids, and <2ft bank-full width
9- Unclassified	U1- Untyped	
	U2- Artificial link to typed stream	V- Intentionally created streams

Federal/State water quality standards and riparian stream corridor buffer protections both driven in part by the results of formal State water typing. Confusion over the accuracy and applicability of Redmond's locally adopted, stream classification system is therefore likely to diminish appropriate protections for citywide fish bearing streams.

Buffers are the most common method for protecting vegetation and its riparian functions from adjacent land uses. Buffers are vegetated zones located between natural resources, such as streams, and nearby areas subject to human alteration. They are intended to protect an area of sufficient size to provide functions considered important for protecting aquatic and riparian species and to buffer against development impacts. Key functions considered when establishing buffer widths include shade and temperature regulation, flood conveyance, water quality protection and pollutant removal, nutrient cycling, sediment transport, bank stabilization, woody debris recruitment, wildlife habitat, and microclimate control.

There are a number of technical reports that summarize scientific literature on buffer functions and make recommendations for buffer widths. Examples of peer reviewed summaries of Best Available Science data from Puget Sound Lowland riparian stream corridors are presented in the three Tables that follow.

Table 1. Riparian Buffer Functions and Appropriate Widths Identified by May (2000)

Function	Function Range of Effective Buffer Widths	Minimum Recommended	Notes On Function
Sediment Removal/Erosion Control	26 - 600 ft (8 – 183 m)	98 ft (30 m)	For 80% sediment removal
Pollutant Removal	13 - 860 ft (4 - 262 m)	98 ft (30 m)	For 80% nutrient removal
Large Woody Debris Recruitment	33-328 ft (10 –100 m)	262 ft (80 m)	1 SPTH based on long-term natural levels
Water Temperature Protection	36 - 141 ft (11 – 43 m)	98 ft (30 m)	Based on adequate shade
Wildlife Habitat	33 - 656 ft (10 – 200 m)	328 ft (100 m)	Coverage not inclusive
Microclimate Protection	148 - 656 ft (45 – 200 m)	328 ft (100 m)	Optimum long-term support

Table 2. Riparian Functions and Appropriate Widths Identified by Knutson and Naef (1997)

Function	Range of Effective Buffer Widths
Water Temperature Protection	35 - 151 ft (11 - 46 m)
Pollutant Removal	13 - 600 ft (4 - 183 m)
Large Woody Debris Recruitment	100 - 200 ft (30 - 61 m)
Erosion Control	100 - 125 ft (30 - 38 m)
Wildlife Habitat	25 - 984 ft (8 - 300 m)
Sediment filtration	26 - 300 ft (8 - 91 m)
Microclimate	200 - 525 ft (61 - 160 m)

Table 3. Riparian Functions and Appropriate Widths Identified from FEMAT (1993)

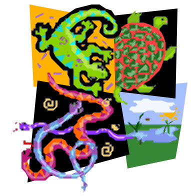
Function	Number of SPTH	Equivalent Based on SPTH of 200 ft (m)
Shade	0.75	150 ft (46 m)
Microclimate	up to 3	up to 600 ft (183 m)
Large Woody Debris	1.0	200 ft (61 m)
Organic Litter	0.5	100 ft (30 m)
Sediment Control	1.0	200 ft (61 m)
Bank Stabilization	0.5	100 ft (30 m)
Wildlife Habitat	-----	98 - 600 ft (30 - 183 m)

There is no consensus in the scientific literature regarding single buffer widths for particular functions or to accommodate all functions. However, a buffer width equal to one site potential tree height would provide for a broad range of riparian functions important for sustaining salmonids. Site potential tree height is defined as the average maximum height to which a dominant tree (age between 200 to 500 years old) will grow if left undisturbed. This is dependent upon species, soils, climate, and disturbance history of a site. For Douglas Firs, this range is 198 to 218 feet.

Fixed buffer widths, versus variable buffer widths, are easily established, have a lower need for specialized personnel with a knowledge of ecologic processes, and require less time and money to administer. Variable buffer widths theoretically can potentially allow for greater flexibility, account for variation in site conditions and land management practices, and potentially achieve desired ecological goals while minimizing undue losses to landowners. However, there are no generally accepted criteria for the establishment of variable width buffers.

Buffers for lakes and ponds are used for water quality protection, but there is an absence of scientific literature assessing functions or effectiveness of buffer widths for lakes and ponds. It is likely woody debris plays a role in diffusing wave energy. Terrestrial food sources, overhead shading (for hiding cover rather than temperature), bank stability, and pollutant removal are likely similar for lakes as those affecting riverine areas.

Landscape scale measures are needed to protect functions such as hydrology, sediment routing, and nutrient cycling that largely originate outside of the immediate riparian corridor. Forest retention on a watershed scale has been implemented by King County in the Bear Creek Basin. The Tri-County Model proposes a “65/10” standard in **rural** areas. This means retaining native vegetation on at least sixty-five percent (65%) of the parcel and restricting the amount of effective impervious surface to no more than ten percent (10%) through application of runoff dispersion and infiltration techniques. The “65/10” standard was based on the estimated point when land use and land cover changes are observed to cause downstream channels to start to become seriously degraded. In developing areas, there are a number of measures recommended for effective protection of aquatic areas. These include minimizing impervious surface, forest retention policies, stormwater detention with quality controls, maintaining riparian buffers, protection of wetlands, and no construction on steep or unstable slopes.



Wetlands

Definition/Description

Wetlands are areas in the landscape that have certain characteristics that support wetland vegetation. Within scientific and regulatory circles, there are a number of definitions. However, in the State of Washington, cities and counties are required to apply the definition of a “wetland” within the Growth Management Act, which reads:

> *"Wetland" or "wetlands" means areas that are inundated or saturated by surface water or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas. Wetlands do not include those artificial wetlands intentionally created from nonwetland sites, including, but not limited to, irrigation and drainage ditches, grass-lined swales, canals, detention facilities, wastewater treatment facilities, farm ponds, and landscape amenities, or those wetlands created after July 1, 1990, that were unintentionally created as a result of the construction of a road, street, or highway. Wetlands may include those artificial wetlands intentionally created from nonwetland areas created to mitigate conversion of wetlands.*[1]

Wetlands are identified using the <u>Washington Wetlands Identification and Delineation Manual</u>. The following summarizes resources available for wetland identification. The City of Redmond possesses maps that illustrate those areas of the City that have a higher probability of exhibiting wetland characteristics. These maps are based upon the National Wetlands Inventory and the Soil Survey of King County.

The National Wetlands Inventory, or NWI, was developed by the Department of the Interior. The data was defined by evaluating aerial photographs. Those areas that appeared to exhibit wetland vegetation through these aerial photographs were delineated on maps. In various cases, field checks were later done for quality control. The Department of Interior, in identifying wetlands, did not

[1] RCW 36.70A.030 (20).

identify those wetlands that were involved in agricultural production at the time.

The United States Department of Agriculture's Soil Conservation Service, now called the Natural Resource Conservation Service, developed the Soil Survey for King County. The Soil Survey was created through the application of geological data and by field tests. Although designed primarily for agricultural uses, the Soil Survey identifies areas of hydric soils. Hydric soils are areas that tend to exhibit wetland characteristics.

Both the NWI maps and the Soil Survey are useful for identifying areas where wetlands can exist; however, each has its shortcomings. In addition to not accurately depicting all wetlands by omitting certain wetlands, such as those in agricultural production (NWI), the maps are generally not as accurate at identifying field conditions down between two and five acres. The scale differs from area to area, depending upon the level of analysis completed in the field. Finally, while recognizing data gaps in these references, it is important to understand that the NWI and Soil Survey data layers used in the City's geographic information system appear to be inaccurate in some sections of the City, when compared to field conditions.

As a result of the data gaps, it is important to understand that actual field conditions always supercede information available through the City, the NWI, or the Soil Survey. When evaluating an application, City staff must not strictly rely on existing inventories, but should consider requiring an applicant to hire a consultant to perform on-site field determinations where: (1) maps illustrate the potential for wetlands on or within 300' of a project site, (2) streams, ditches, or floodplains are on or within the maximum buffer width of a project site, (3) contour lines indicate a depression or a draw on or within the maximum buffer width of a project site, (4) there is knowledge of a wetland that has been delineated on or within the maximum buffer width of a project site, (5) an on-site field inspection reveals the indicators that a wetland may be present on or in close proximity to a project site, or (6) public or agency comments describe site characteristics that may be indicators of a wetland (e.g. poor drainage, springs, vegetation, etc.).

As previously stated, when wetlands are identified in the field, they shall be identified using the *Washington Wetlands Identification and Delineation Manual*. Before 1997, wetlands were delineated by using the Corps of Engineers Wetlands Delineation Manual (1987 Manual). In 1989, a new manual was developed by the Army

Corps of Engineers. Although similar in many ways to the 1987 Manual, the 1989 Manual produced different results, often including more areas as wetlands than would have occurred with the 1987 Manual. The 1987 Manual became the standard again. In the early 1990's a third manual was under consideration at the federal level. Amid this history of a moving target for defining wetlands, the State of Washington decided to require the Department of Ecology to develop a Manual for the State of Washington. In 1997, this project was completed with the adoption of the *Washington Wetlands Identification and Delineation Manual*, or "State Manual. The State Manual has been designed to produce identical results as the 1987 Manual, therefore using the State Manual should meet requirements on both the State and Federal levels, until the manuals are revised again.

The State Manual provides a detailed description of the methods that must be employed in identifying and delineating wetlands. Wetland Scientists are required to document how they employed these methods through a report. The report has minimum requirements that are described in the State Manual. Attachments, including maps, data sheets, citations to literature, etc., must be provided to support the report.

Wetlands in Redmond

Although wetlands can be found scattered throughout the City, wetlands generally occur along stream corridors and the Sammamish River and Bear Creek Valleys. There are numerous seeps in the ravines along the hillside west of Willows Road where wetlands have been confirmed during the development review process. There are large areas of wetlands along the north end of Lake Sammamish, near the beginning of the Sammamish River. Wetlands have also been identified in north Redmond, particularly along stream headwaters and seeps.

Functions and Values

The Growth Management Act requires that wetland "functions and values" be protected. The terms wetland "functions and values" have changed over the last decade. With the application of best available science, it is generally recognized that "functions" are those processes that characterize a wetland, regardless of human interpretation. "Values" are judgments that people make regarding the processes that a wetland performs and the fact that a wetland exists. Wetland functions include: flood attenuation, water storage, groundwater recharge, water quality maintenance, nutrient absorption, and fish and wildlife habitat. Wetland values include: open space, a place for recreation, education and scientific study, an opportunity for economic gain or source of economic loss.

Because society "values" wetlands, the State of Washington has decided that wetland functions must be protected through regulation. Local governments must determine, with direction from the State and best available science, how wetland functions can be protected. The balance of this document summarizes what scientific studies have found regarding the best available methods for protecting wetland functions and, therefore, for preserving a resource that the State has determined is of "value".

It is important to understand those functions present in any give wetland, as well as how well those functions are performed. In the past, agencies have allowed wetland scientists to apply "best professional judgment" in evaluating wetland functions. Given that "best professional judgment" varies from scientist to scientist, using this fails to provide consistent assessments of the functions in a wetland. The lack of consistency causes difficulties in determining the impacts that are likely to be caused by a development and difficulties in establishing a baseline and in measuring the change in wetland functions after development occurs. It is important, for regulatory purposes and for the purposes of complying with Best Available Science, that consistent methods are used by all wetland scientists and regulators.

The Best Available Science has identified two assessment methods that should be used. They are the Linear Method and the Washington State Function Assessment Method. These methods were developed by the State of Washington and reflect the most current science on assessing a wetland's functions.

Key Protection Strategies

Not all wetlands are "created equal". Each and every wetland functions differently and reacts differently to changes in the environment, whether anthropogenic or environmental. For ease of regulation, the Department of Ecology characterizes wetlands into classes. Colloquially called a "rating system", the *Washington Wetland Rating System* is a method for characterizing wetlands into four classes. The characterization separates wetlands according to common functions, sensitivity to environmental and anthropogenic changes, and uniqueness. The higher "functioning", most "sensitive", and most "unique" wetlands fall into the "Category I" Classification, while the lower "functioning", less "sensitive", and most “common” wetlands fall toward the “Category IV” classification.

Given the method by which wetlands are characterized into groups, regulations have been developed to protect wetlands according to their characterization, rather than on a case by case basis. In the past, it has not been uncommon for different jurisdictions to use different characterization systems. In fact, within the City of Redmond, the existing Sensitive Areas Regulations characterize wetlands using a different method than that developed by the State. The method is also different than that used by surrounding jurisdictions, including King County. This creates challenges in having consistent methods for identifying wetland “quality” and in applying regulatory tools (such as buffers, compensatory mitigation, etc.). Finally, having different methods creates challenges for developers and consultants as Redmond’s regulations are different than those used by the State and other jurisdictions. For these and other reasons, the Best Available Science reflects that it is important for every jurisdiction to use similar methods for characterizing wetlands. The Best Available Science guides the City of Redmond replace the existing method of wetland characterization and replace it with the *Washington Wetland Rating System*.

Sequencing is a term used at the federal level to describe the “triage” system of how wetland impacts can occur. This is known as mitigation sequencing. It requires that an applicant and the City consider different alternatives before a wetland impact can occur. If a wetland impact is permitted, then the system describes the preferred order those impacts can occur. The first step is to avoid the impact altogether by not taking a certain action or parts of an action. The next step is to minimize the impacts by limiting the degree or magnitude of the action and its implementation. The third step is to rectify the impact by repairing, rehabilitating, or restoring the affected environment. The next step is to reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action. The fifth and final step is to compensate for the impact by replacing or providing substitute wetlands.

Buffers are defined by an agency, such as the City of Redmond. Buffers areas of upland that run parallel to a wetland boundary, and are generally intended to be areas that are characterized by beneficial, native vegetation. Development is generally prohibited in buffers.

The scientific literature widely recognizes that buffers are an integral element in protecting wetland functions. By providing buffers, an area of land, often called an ecotone, is maintained. This ecotone serves a number of functions that support a wetland. The buffer serves a biological need by providing shade for the wetland and by supporting habitat for wetland species, which rely on both wetland and upland habitat throughout their life cycle. The buffer also serves a physical and chemical need by attenuating sound, wind and light, by filtering excess nutrients and potential toxicants in runoff, and by reducing water flow rates and sedimentation.

Buffers are typically applied according to a wetland's classification, as determined by a method of characterization. As recommended by City staff, this method may become the *Washington Wetland Rating System* (see previous discussion). Those wetlands characterized as "Category I" would receive higher level of protection while those that are characterized as "Category IV" would receive a lower level of protection.

Buffers vary in widths, which are defined by an agency, with substantial deference to the scientific literature and agencies that specialize in wetland protection. Generally, buffers have been determined by applying the width that would be needed to protect the most sensitive wetland function, which is often wildlife habitat.

The Department of Ecology is expected to publish the Draft best available science document entitled *Freshwater Wetlands in Washington, Volume 2 – Managing and Protecting Wetlands*, in August 2004. This document was previously expected to be published in early 2004. Unfortunately, as of the time of writing this Summary and Review of BAS for Wetlands, this information has yet to be published. Although this document has not been published nor peer reviewed, Volume 1, which has completed peer review, but not been "finalized" provides some guidance on buffer requirements as follows:

> "*For the protection and maintenance of wildlife habitat functions of wetlands, … studies suggest that effective buffer widths should be based on the above factors and generally should range from 25 to 75 feet … for wetlands with minimal habitat functions and adjacent low-intensity land uses; 50 to 150 feet for wetlands with moderate habitat functions or high-intensity lands use that is adjacent; and 150 to 300 feet for wetlands with high habitat functions.*"[2]

[2] Freshwater Wetlands in Washington State, Volume 1, A Synthesis of the Science, Draft, August 2003,

In addition to the Draft of Volume 1, cited above, the Department of Ecology has placed a "Preliminary Draft" of Appendix 8-C, *Draft Guidance of Buffers and Ratios for Compensatory Mitigation to be Used with the Western Washington Wetland Rating System,* on the State's website.[3] That Guidance is expected to be incorporated into Volume 2 when it is published in draft in August 2004. The draft offers three alternatives for applying buffers to wetlands. It should be noted that in all cases, the recommended buffers are, "based on the assumption that the buffer is vegetated with a native plant community appropriate for the ecoregion or with one that performs similar functions".

The *Draft Guidance* provides three alternatives for local governments to apply buffers. They are:

Alternative 1: *Width based only according to wetland category.* This alternative offers the least flexibility of the three alternatives. Further, it does not recognize that some wetlands within a Category do not need as wide of a buffer as others. However, the one-size-fits-all approach reduces the need for local jurisdictions to maintain specialized staff or hire professional wetland consultants to review the more technical material required for the other alternatives. Further, the one-site-fits-all approach reduces those instances where two wetlands within the same category have different buffers because of certain functions that exist at one wetland but not the other. For Alternative 1, the *Draft Guidance* would simply require:

Category	Buffer Width
I	300'
II	300'
III	150'
IV	50'

Alternative 2: *Width based on wetland category and modified by impacts of proposed land uses*. Alternative two "increases the regulatory flexibility by including the concept that not all types of proposed land uses have the same level of impact."[4] The required buffers are more complicated as

page 5-53, Chapter 5.

[3] http://www.ecy.wa.gov/programs/sea/bas_wetlands/pdf/draft_appendix8-c-westernwaguidance.pdf

[4] *Freshwater Wetlands in Washington, Volume 2 – Managing and Protecting Wetlands, Appendix 8-C, Guidance on Buffers and Ratios – Western Washington, July 2004, Page 3.*

buffers are defined by the “land use impact” as low, moderate, or high. The Draft Guidance defines these terms on page 4 of Appendix 8-C. Generally[5]:

- High Intensity Uses are commercial, urban, industrial, residential exceeding one unit per acre, golf courses, ball fields, and soccer fields.
- Moderate Intensity Uses are residential fewer than one unit per acre, more wooded parks that require less manipulation than for those recreational uses listed above, and paved trails.
- Low Intensity Uses are low intensity open space such as passive recreation and natural resources preservation, unpaved trails, and forestry (cutting of trees only).

With these use-intensities in mind, the buffers would be:

Category	Low	Moderate	High
I	150’	225’	300’
II	100’	150’	300’
III	75’	110’	150’
IV	25’	40’	50’

While this offers more flexibility than Alternative 1 in concept, it may be observed that most of the uses in the City of Redmond would be considered “High Intensity” uses by way of the State’s definitions for the use-intensities.

Alternative 3: *Width based on wetland category, intensity of proposed impacts, and wetland functions or special characteristics.* Alternative 3 is the most complicated option, although it offers the most flexibility in concept. Given the complexity, the reader is simply referred to the *Draft Guidance*, page 4. The *Draft Guidance* relies on three pages of tables to define the buffer widths. Generally, buffer widths vary as follows:

- Wetlands are not simply categorized to determine their buffer requirements, but they further subcategorized according to each individual wetland’s “score” on general functions and on more specific functions. The more specific functions that are considered as requiring wider buffers are habitat and water quality. Further, “special wetlands” such as Natural Heritage Wetlands, bogs, and forested wetlands also are regulated with different buffers.
- Buffers are influenced in a manner similar to Alternative 2

[5] *This is not an all-inclusive list. Please refer to the Draft Guidance for a complete listing.*

(above) by applying different buffers according to the use-intensity for most wetland categories and accordance with “function scores”.

- Finally, mitigation measures are defined to allow the buffers. Unfortunately, the *Draft Guidance* is currently incomplete and in many cases the mitigation measures are listed as “*To be developed*” as of the writing of this summary.

The result of Alternative 3 is that it is possible to have narrower buffers than would otherwise be allowed by Alternatives 1 and 2. However, it would be relatively more complex to administer.

There are cases where an applicant desires to reduce the required buffer. Under current City regulations, buffers can generally be reduced where the buffer and wetland are enhanced. Enhancing a wetland or buffer generally involves removing invasive species of plants and re-planting with species that provide more opportunities for wildlife. These opportunities include providing habitat and sources of food.

The *Draft Guidance* provides opportunities for reducing buffer widths for high intensity land uses to those buffers required for moderate intensity impacts. These opportunities apply according to the habitat score for the subject wetland. The following is a summary:

Condition 1: Reducing the Intensity of Impacts Caused by Proposed Land Uses

1. Habitat score of greater than or equal to 20: The width can be reduced if both of the following criteria are met:
    a. A vegetated corridor of at least 100’ is protected between the wetland and any other Priority Habitats. The corridor would be protected by a recorded instrument, such as a conservation easement.
    b. Impacts from the use are minimized by taking certain actions in the design and operation of the use being proposed. Examples include directing lighting away from wetlands, routing runoff away from the wetland, and restricting access to the area by pets and humans.

2. Habitat score of less than 20 points. The width can be

reduced if actions in 1 b of the previous paragraph in this summary are met.

Condition 2: Reductions in Buffers for Existing Roads or Structures within the Buffers. Generally, this applies to legally established, non-conforming uses. Uses can be continued and expanded as long as they do not increase the degree of non-conformity.

The *Draft Guidance* has requirements that buffers be enhanced where

- The buffer is not vegetated with plants appropriate for the region. This is required because, as noted under above, the buffers in the alternatives only apply where the buffer is already characterized by beneficial, native vegetation.
- The buffer has a steep slope. This is required because steep slopes do not have the same capacity to absorb and treat water as flatter land. Consequently, the increased buffer is intended to provide the additional land necessary to perform a similar function as more level land.
- The buffer is used by sensitive species. Where sensitive species exist adjacent to wetlands or their buffers, it may be necessary to extend the buffer to provide for better protection of that species' habitat.

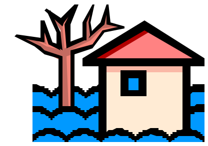
Wetlands do not typically have smooth boundaries. Consequently, as a wetland buffer is applied, the edge of the buffer, which parallels and reflects the boundary, can be highly irregular. The irregular nature of this buffer edge can create circumstances where it is difficult to determine the extent of the boundary, which creates challenges for both compliance with and enforcement of critical areas codes. Buffer width averaging is introduced as a tool to "smooth out" a wetland buffer's edges, thus allowing for easier description in recorded document and easier delineation in the field.

Although the Department of Ecology states that "there is no scientific information available to determine if averaging of widths of buffers does actually protect the functions" of a wetland, the *Draft Guidance* does provide direction on how averaging can occur. The following summarizes this direction:

- Averaging may not be used in conjunction with provisions for buffer width reduction;
- Averaging may be permitted where averaging is proposed to improve wetland function, when certain criteria are met; and
- Averaging may be permitted to allow reasonable use of property when certain criteria are met.

Compensatory mitigation includes: creating new wetlands, enhancing existing wetlands, preserving existing wetlands, and restoring previously existing wetlands. Studies show that compensatory mitigation has not been very successful. Of these, the least successful at mitigation is enhancement. Generally, the lack of success is due to inadequate follow up by all parties, including agency personnel.

Complimentary protection strategies to the above include fencing off wetlands and their associated buffers and requiring the wetland and buffer have a permanent protective measure, such as a native growth protection easement or be placed in a separate native growth protection area (separate tract) on which development is prohibited.



Frequently Flooded Areas

Definition/Description

A floodplain is the generally flat, low-lying area adjacent to a river or stream that is periodically flooded by overbank flows during storm events. Frequently Flooded Areas are those open-channel and overbank areas in the floodplain that are periodically inundated with floodwater.

Frequently Flooded Areas coincide with the Federal Emergency Management Agency (FEMA) or Flood Insurance Fate Maps (FIRM) flood hazard areas. FEMA delineates flood hazard areas along major river and stream corridors to identify areas that are at risk from floodwaters. This information is used for both floodplain management and insurance rating. These areas are mapped by delineating the 100-year floodplain. These areas are subject to a one-percent chance of flooding in any given year. A specific portion of the 100-year floodplain which allows for the complete conveyance of the base flood is called the floodway. The base flood is the flood that has a one-percent change of occurring in any given year. The backwater area that includes shallow flow and ponded areas is the flood fringe. The floodway and the flood fringe areas combined represent the 100-year floodplain.

FEMA regulations allow for a one-foot rise in the floodplain. Current city regulations establish a zero-rise floodway. This is more restrictive than the FEMA guidelines. The zero-rise floodway area allows for the complete conveyance of the fast moving water, or base flood, without a rise in elevation. As such, the zero-rise floodway is wider than the FEMA floodway.

Frequently Flooded Areas in Redmond

In Redmond, Lake Sammamish, the Sammamish River, Bear Creek, and Evans Creek have associated 100-year floodplains which have been mapped by FEMA. The 100-year floodplain elevation for Lake Sammamish is 33 feet, well above the lake's ordinary high water mark. The 100-year floodplain of the Sammamish River historically has been the majority of the valley floor. Straightening of the river in the 1960's by both the local drainage district and the Army Corps of Engineers has resulted in a uniform trapezoidal channel designed to contain the 40-year spring flood event. This has resulted in a highly altered river system that has severed historic connections with the flood fringe and outlying wetlands. Portions of Bear Creek, particularly east of Avondale Road, have floodplains extending over one hundred feet from the creek. These areas have maintained their hydrologic connection. Other portions of Bear Creek, however, have been relocated from their naturally occurring locations. Portions of the floodplain in these areas have succumbed to development, including road construction. The City, along with other agencies, is focusing efforts on rebuilding and enhancing the previously relocated and degraded sections of Bear Creek. Evans Creek flows into Bear Creek in southeast Redmond. Development has encroached into the creek's riparian corridor along the majority of its reach in the City.

Functions and Values

Frequently Flooded Areas provide a variety of functions. During flood events, large volumes of water and debris move downstream. Floodplains provide for the storage and transport of water during storm events. Floodwaters transport sediments and nutrients that replenish the floodplain lands. Floodwaters move and distribute large woody debris that builds structure and creates the physical characteristics of the main channel and side channel. Flooding therefore acts to provide connectivity between the river or stream, its riparian soils, and vegetation. Natural floodplains additionally provide aquatic and riparian habitat for a wide variety of fish and wildlife.

Clearing rivers and stream of vegetation and large woody debris increases the conveyance capacity of floodwaters at risk to other functions and values of the floodplain. Bank erosion may increase and the ability to trap and store sediments and nutrients important for aquatic life decreases. The lack of shade may increase water temperatures. Removal of large woody debris simplifies the physical structure of the channel and affects the ability for the stream or river to form pools, an important component to salmon habitat.

Key Protection Strategies

The Growth Management Act requires functions and values of critical areas be protected. The goal is to attain no net loss of the structure, value, and functions of natural systems constituting Frequently Flooded Areas. Therefore, the current day strategies in floodplain management focus on no net impact. This essentially means that the floodplain action of one property owner or community does not adversely affect the flood risks for other properties or communities as measured by increased flood stages, increased flood velocity, increased flows, or increased potential for erosion and sedimentation, unless the impact is mitigated. Regulatory examples to help achieve this are providing compensatory floodplain storage and prohibiting increases in flood elevations. Floodplain structural solutions may include reconnecting side channels and wetlands, and establishing backwater areas reestablishes floodstorage areas and restores vital aquatic and riparian areas. Future conditions hydrology can be used to estimate the floodplain boundaries at full built out conditions of a basin. Depicting a future conditions floodplain would serve to alert the public to potential, future hazards and further the understanding of potential effects to the natural habitat and aquatic resources.

A representative of the Department of Ecology, as the State Coordinating Agency for the National Flood Insurance Program, came to Redmond for the City's Community Assistance Visit in September 2003. They performed a thorough review of the City's regulations pertaining to floodplains. A recommended list of changes was identified, most stemming from the gaps identified from a comparison of the City's regulations with Ecology's Model Flood Damage Prevention Ordinance. As a result, the City adopted changes to Chapter 15.04, Flood Control, of the Redmond Municipal Code in April 2004. The recommended edits to the floodplain regulations in the Redmond Community Development Guide will be incorporated as part of the Critical Areas Ordinance Update.

Critical Aquifer Recharge Areas

Definition/Description

Critical Aquifer Recharge Areas are areas where an aquifer used for drinking water is vulnerable to contamination from surface activities. Such areas include, but are not limited to, sole source aquifer recharge areas and wellhead protection areas designated under the federal Safe Drinking Water Act, and areas established for special protection under a state or local groundwater management program.

The risk of groundwater contamination depends on two main sets of conditions. One set of conditions relates to the ground itself and how easily it is for water to pass through to groundwater. If soils and the underlying area are very permeable and the groundwater table is shallow, then the hydrogeologic conditions are susceptible to contamination. In addition, a source of recharge, like rain, must be present before contaminants would be carried down to the water table. This is what is meant by hydrologic susceptibility.

The other set of conditions relate to how likely it is for potential contaminants to reach groundwater. The amount of potential contaminant material, chemical composition, and how the material is handled all contribute to how easily potential contaminants may reach ground water. This is commonly known as contamination loading potential or source loading. To determine the threat to groundwater quality, existing land use activities and their potential to lead to contamination should be evaluated.

Hydrologic susceptibility provides the basis for classifying critical aquifer recharge areas in terms of relative risk of contamination. Evaluation of potential contaminant loading provides information for policy, planning, management, and regulation of land uses that pose a risk to highly susceptible areas so that contamination can be prevented.

Vulnerability is the combined effect of hydrogeologic susceptibility to contamination and the contamination loading potential. Vulnerability represents the risk that an aquifer could become contaminated by potential sources of pollution.

The term wellhead protection is defined by the U.S. Environmental Protection Agency in the 1986 amendments to the Safe Drinking Water Act. Wellhead refers to a water supply and the water that is produced by that well from the water-bearing strata (aquifer) in which the well is completed. Wellhead protection involves the management of activities that have the potential to degrade the quality of groundwater produced by a supply well.

Critical Aquifer Recharge Areas in Redmond

The City obtains its water supply from two sources: City water supply wells and a City of Seattle surface water pipeline. The area east of the Sammamish River is served by City wells and the area west of the river and Lake Sammamish is supplied by water from the Tolt Eastside Supply Line. Water can be piped between these areas with two interties.

Redmond has developed a program to protect the quality of the portion of the drinking water supply that is obtained from city wells. In 1994, the City received a wellhead protection grant from the Department of Ecology under the Centennial Clean Water Fund. The grant funded steps to: establish a wellhead protection committee; define wellhead protection areas; complete a wellhead inventory (of potential contamination sources); develop wellhead protection area management strategies; prepare contingency and spill response plans; prepare guidelines for a wellhead protection program; and project management.

In 1997, Parametrix, Inc. produced a Wellhead Protection Report for the City of Redmond. The report gives a brief description of the City's water supply system and previous groundwater protection efforts. It includes a technical discussion of the Redmond aquifer hydrogeology and delineation of wellhead protection areas using an analytical element model. Potential sources of groundwater contamination were inventoried and assessed. A water supply contingency and spill response plan is described. A public involvement program was implemented and is detailed in the report. Wellhead protection strategies and wellhead protection program implementation recommendations are described.

One of the many outcomes of this 1997 report was the 2003 adoption of a wellhead protection ordinance for the City. It establishes wellhead protection zones based on proximity to and travel time of groundwater to the City's public water supply wells. Wellhead Protection Zone One represents the land area overlying the six-month time-of-travel zone of any public water source well owned by the City. Wellhead Protection Zone Two represents the land area that overlies the one-year time-of-travel zone of any public water source well owned by the City, excluding land area contained within Wellhead Protection Zone One. Wellhead Protection Zone Three represents the land area that overlies the five-year and ten-year time-of-travel zones of any public water source well owned by the City, excluding land area contained within Wellhead Protection Zones One and Two. Wellhead Protection Zone Four represents all remaining land area in the City not included in Wellhead Protection Zones

One, Two, or Three. Geographically, these Wellhead Protection Zones tend to follow along Bear Creek.

In 1986, Ecology designated the Redmond-Bear Creek Ground Water Management Area per criteria established by WAC 173-100, Groundwater Management Areas and Programs. The Ground Water Management Area covers an area of approximately 50 square miles bounded by the Snohomish County line on the north, the Bear Creek basin divide on the east, Lake Sammamish on the south, and the Sammamish River on the west. Redmond supply wells produce from the Alluvial Aquifer with screen bottom depths of 20 to 68 feet below ground surface. The Alluvial Aquifer from which Redmond draws its water is located within this Ground Water Management Area. The Redmond-Bear Creek Ground Water Advisory Committee was formed in 1988 to guide development of the Redmond-Bear Creek Groundwater Management Plan according to state regulation. Data collection and analysis occurred between 1989 and 1992. A draft Ground Water Management Plan was produced in 1994, followed by a public hearing in 1995. An updated draft plan was produced in 1996 and the Department of Ecology certified the Plan in 2000. Although the plan has not been formally adopted by Redmond, City staff participates on the Groundwater Advisory Committee and work towards plan implementation.

Functions/Values

Critical Aquifer Recharge Areas provide sources of potable water. They also provide areas for replenishment of groundwater resources.

Key Protection Strategies

The Growth Management Act requires jurisdictions to designate and protect areas critical to maintaining groundwater recharge and quality primarily to maintain the quality of potable underground water supplies. Key Critical Aquifer Recharge Area protection strategies include a combination of efforts. Critical Aquifer Recharge Area ordinances, including Wellhead Protection Ordinances, are a key regulatory tool. An important non-regulatory tool that can supplement the current and proposed rules and regulations is education and outreach. This can be crucial in protecting groundwater from residential sources of contamination. Lastly, inspection and compliance programs are a key component to the protection of groundwater. The rules and regulations cannot be effective without a mechanism for enforcement.

Geologic Hazard Areas

Definition/Description

Geologic Hazard Areas include areas susceptible to erosion, sliding, earthquake or other geologic events. They pose a threat to the health and safety of citizens when incompatible residential and non-residential development is sited in areas of significant hazards.

Erosion hazard is a measure of the susceptibility of an area of land to prevailing agents of erosion. In general, the finer-grained the soil, the more erosive it is. The steeper the slope, the more likely excessive erosion occurs due to higher runoff energy. Numerous variables are at work, including grain-size, soil cohesion, slope gradient, rainfall frequency and intensity, surface composition and permeability, and the type of cover. All of these factors help determine the severity of the erosion hazard.

Landslide Hazard Areas are potentially subject to landslides based on a combination of geologic, topographic, and hydrologic factors. They are areas of the landscape that are at a high risk of failure or that presently exhibit downslope movement of soil and/or rocks and that are separated from the underlying stationary part of the slope by a definite plane of separation. The plane of separation may be thick or thin and may be composed of multiple failure zones depending on local conditions including soil type, slope gradient, and groundwater regime. Examples of Landslide Hazard Areas may include: areas of historic failures; areas designated as quaternary slumps or landslides on maps published by the United States Geologic Survey (USGS); areas containing slopes steeper than fifteen percent (15%), springs or groundwater seepage, and hillsides intersecting geologic contacts with a relatively permeable sediment overlying a relatively impermeable sediment or bedrock; slopes that are parallel or subparallel to planes of weakness in subsurface materials; areas potentially unstable as a result of rapid stream incision, stream bank erosion, and undercutting by wave action; and any area with a slope forty percent (40%) or steeper.

The rate of movement for a landslide may be very slow or very fast. In either case, the soils mass can and does cause catastrophic damage to structures that lie above it or that lie in its path. Landslides that move swiftly may strike structures before they can be evacuated.

Landslides can be triggered from rainfall, when water percolates down through the more permeable sands and silty sands until it hits a silt or silty clay layer. The water then flows laterally along the upper surface of the impermeable layer until it daylights. Often the water cannot move as fast laterally as it is raining. As a result, when the water builds up the pore pressure increases and the soil mass as a whole begins to lose its sheer strength. At some point, the top layer begins to slide under the influence of gravity. Landslides can also be triggered when there is a loss of later support at the bottom or toe of a slope.

Removal of vegetation can have a dramatic affect on slope stability. Denudation results in rapid runoff and saturation of surficial soils that consistently leads to failures. Vegetation and the organic duff layer of the earth's surface reduce the energy of rain splash and greatly reduce erosion. Vegetation removes water from the soil matrix through its roots and stores it in the body of the plant, until it is released back into the atmosphere through evapotranspiration.

Vegetation root mass can also impact slope stability. Depending on species, plant density, and slope geometry, its tensile strength that is imparted to the soil matrix by the root mass can be enormous. Removal or killing the plants and rotting of the root mass reduces this tensile strength and can destabilize an otherwise stable or marginally stable slope.

Seismic Hazard Areas are those areas subject to severe risk of damage as a result of earthquake induced ground shaking, slope failure, settlement, soil liquefaction, surface faulting, or subsidence and uplift. Severe risk of damage is loosely defined as damage that is structural rather than cosmetic. One indication of potential for future earthquake damage is a record of past earthquake damage. In Washington, ground shaking is the primary cause of earthquake damage and the strength of groundshaking is primarily a factor affected by: the magnitude of the earthquake; the distance from the source of an earthquake; the type of thickness of geologic materials at the surface; and the type of subsurface geologic structure. Natural and artificial unconsolidated materials, such as materials used as landfill, commonly amplify ground motion relative to motion in consolidated sediments and bedrock.

Settlement and soil liquefaction conditions occur in areas underlain by cohesionless soils of low density, typically in association with a shallow groundwater table. Liquefaction occurs when very loose to loose, saturated sand or silt is shaken violently enough to increase pore water pressure between individual grains effectively reducing shear strength of the soil mass. Shallow liquefaction zones can cause severe damage to structures whose foundation support has suddenly become fluid.

Surface faulting, a major fault rupture at the surface, can be extreme. Buildings may be torn apart, gas lines severed, and roads made impassible. Damage by faults is more localized than the widespread damage caused by ground shaking.

Subsidence and uplift results in a sudden elevation change. Major subsidence and uplift of large regions often occurs as a result of great subduction style, thrust earthquakes.

Geologic Hazard Areas in Redmond

Erosion Hazard Areas are found throughout the City. On a relative basis, the areas with critical or more severe potential for erosion in Redmond occur along the sloping hills of the Sammamish Valley, scattered along the perimeter slopes of Education Hill, and in pockets of steep slopes south of NE 40th Street and east of 172nd Avenue NE.

In Redmond, potential Landslide Hazards generally occur along the steep slopes of the Sammamish Valley and Education Hill, although there are pockets of scattered landslide hazard areas throughout the City. Three know recent landslides occurred along the backside (Avondale Road side) of Education Hill in the 1990s.

In general, the lands of the Sammamish River Valley and Bear Creek Valley are considered to be Seismic Hazard Areas. This is largely due to a combination of the underlying soils and ground water conditions, elevating the risk of groundshaking, subsidence or liquefaction during earthquakes.

Functions and Values

Some erosion is natural and is important to the overall function and health of a stream system. Natural erosion and landsliding processes provide the sand, gravel, cobbles, and boulders that streams need to remain productive with respect to fish and other aquatic organisms. It is difficult, however, to determine what the natural background level of sediment input is and what exceeds it. Excessive erosion can be very damaging to water quality in adjacent and downstream waterbodies, including those that support salmonid fish and other species. Silt and sand-sized particles are damaging to the stream environment if excessive deposition occurs. This material can bury and asphyxiate fish eggs that are deposited in gravel, and can fill spaces between gravel that support aquatic insects, and can even kill fish by damaging or clogging the gill structure. Additionally, erosion leading to deposition of materials downstream can cause channel in-fill, channel blockage, and blockage to fish passage and loss of local flood storage.

Large woody debris recruitment can occur from landslides. It is very important for the natural function and health of aquatic areas. Large woody debris provides nutrients to the aquatic area, provides shelter from predators to fish and amphibians, provides some shade, and serves to stabilize stream channels.

Key Protection Strategies

The Growth Management Act requires protection of Geologic Hazard Areas primarily to prevent loss of property and human life caused by inappropriate development and development in inappropriate areas.

A key strategy for protection of Erosion Hazard Areas is to promote sound development practices including the use of Best Management Practices (BMPs). The amount of excess sediment that reaches stream systems can be limited by requiring BMPs that limit erosion and sedimentation during construction. A Temporary Erosion and Sedimentation Control (TESC) plan should be prepared for all development activities requiring a permit. Appropriate BMPs and a construction sequence should be included on the TESC plan. BMPs commonly used include covering bare ground with straw and/or plastic sheeting, using silt fences, and by planting exposed soil as soon as possible after development.

Establishment of buffers around the perimeter of Landslide Hazard Areas is the best way to avoid the potential to undermine these areas or avoid the risk to human life and safety.

Due to the nature and inability to predict location and magnitude of seismic events, scientific literature dictates seismic activity can be mitigated to some degree. Strategies revolve around regulatory requirements, including preparation of site-specific studies for essential facilities and lifelines, and adherence to building codes that require earthquake resistant design and construction.

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